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IS 4622 (2003): Recommendations for Structural Design of Fixed-Wheel Gates [WRD 12: Hydraulic Gates and Valves]



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भारतीय मानक
स्थिर-व्हील गेट के संरचनात्मक
डिजाइन की सिफारिशें
(तीसरा पुनरीक्षण)

Indian Standard
RECOMMENDATIONS FOR STRUCTURAL
DESIGN OF FIXED-WHEEL GATES
(*Third Revision*)

ICS 93.160

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NEW DELHI 110002

FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Hydraulic Gates and Valves Sectional Committee had been approved by the Water Resources Division Council.

The gate in general, is a structural steel frame consisting of end vertical girders with properly spaced horizontal girders between them. The spacing depends on the design water pressure and on dimensions of the gate. The frame is held a piece by secure welding or riveting. Skin plate protects the structural framework from damage due to ice and heavy debris, minimizes downpull, reduces corrosion and facilitates maintenance. However, in some cases as in the case of fixed wheel gates moving on track provided on the face of the dam, skin plate is provided on the downstream side. In exceptional cases, skin plate is provided on both downstream side and upstream sides, if the down stream water is above sill. In such cases, the gates may be fully or partially buoyant. In case of fully buoyant gates, buoyancy shall be taken into account in determining the net balance of vertical forces and addition of ballast may be necessary to ensure lowering without difficulty. This problem is absent in the case of flooded gates but greater care against corrosion becomes necessary. The wheels are mounted on the end girders. The bottom of gate should be so shaped that satisfactory performance and freedom from harmful vibrations are attained under all conditions of operation apart from minimizing downpull. A typical arrangement of various components of gate is shown in Fig. 1.

This standard was first published in 1967 and was subsequently revised in 1978 and 1992 in the light of experience gained during the course of these years. The first revision incorporated a number of modifications, the prominent among which were the revision of the permissible stresses, inclusion of tolerances and a typical solved example in Annex E. The major changes incorporated in the second revision were the calculation of bending stresses in flat plates, inclusion of formula for calculating the track plate thickness (wheel track with line contact and point contact) and the criteria for determining the edge distance of the bearing flange of track base from groove face.

As a result of increased use of the standard, suggestions have been received for further modifying some of the provisions of the standard, therefore, third revision of the standard is being brought out. In this revision, the method of design of skinplate and stiffeners has been aligned with IS 4623 : 2000 'Recommendations for structural design of radial gates (*third revision*)'.

Provision for defreezing may be made for trouble-free hoisting of gates in sub-freezing weather and shall be in accordance with IS 10021 : 1981 'Guidelines for de-icing systems for hydraulic installation (*first revision*)'.

The criteria laid down for the design of individual component may be used for any other type of vertical lift gate under similar condition.

In the formulation of this standard, due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

For design of concrete and steel structures general reference may be made to the latest version of IS 456 : 2000 'Plain and reinforced concrete — Code of practice (*third revision*)' and IS 800 : 1984 'Code of practice for general construction in steel (*second revision*)' respectively.

The Committee responsible for the formulation of this standard is given in Annex J.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

(Continued on third cover)

Indian Standard

RECOMMENDATIONS FOR STRUCTURAL DESIGN OF FIXED-WHEEL GATES

(*Third Revision*)

1 SCOPE

1.1 This standard provides recommendations guidance for the structural design of fixed-wheel gates for low, medium and high heads (*see* 3) commonly used for spillways, sluices and penstocks in dams and for barrage and canal regulators.

1.2 This standard also applies to such gates installed at inclined positions subject to corresponding changes.

2 REFERENCES

The Indian Standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards.

3 CLASSIFICATION OF GATES

The gates may be classified on the basis of water head above sill level as follows:

- a) *High head gate* — Gate which operates under a head of 30 m and above;
- b) *Medium head gate* — Gate which operates under a head of 15 m and above, but less than 30 m; and
- c) *Low head gate* — Gate which operates under a head of less than 15 m.

4 MATERIALS

The materials generally used for different components are given in Table 1. Any other material satisfying the requirements of the job may also be specified.

5 DESIGN CONSIDERATIONS

5.1 General design of the gates involves design of the following components:

- a) Skin plate;
- b) Vertical and horizontal stiffeners and main girders;
- c) Wheels and wheel tracks;
- d) Seals and accessories;

- e) Guide rollers/guide shoes;
- f) Wheel track and track base;
- g) Guides;
- h) Seal seat, seal base and sill beam; and
- j) Anchorages.

5.1.1 The gate in general shall satisfy the following requirements:

- a) The gate shall be reasonably water tight, the maximum permissible leakage being not more than 5 litres/min/metre length of seal in case of low and medium head gates and 10 litres/min/metre length of seal in case of high head gates. The figure of permissible leakage is the upper limit before which the remedial measures shall be required to rectify defects.
- b) It shall be capable of being raised or lowered by the hoist at the specified speed.
- c) Power-operated gates shall normally be capable of operation by alternate means in case of power supply failure.
- d) If meant for regulation it shall be capable of being held in partially open position within the range of travel to pass the required discharge without cavitation and undue vibration.
- e) Wherever necessary, model studies may be carried out for high head regulating gates.

5.1.2 The gate shall be designed for the hydrostatic and hydrodynamic forces taking into consideration forces arising from wave effects, seismic loads and ice formation wherever applicable.

5.1.3 In addition to water load, the additional water head to the static head to account for the sub-atmospheric pressures downstream of gates located in conduits/sluices should be specified to the designer.

5.1.4 The gate is normally designed to close under its own weight with or without addition of ballast but sometimes it may require a positive thrust for closing, in which case hoists shall be suitable for that purpose.

5.2 Skin Plate and Stiffeners

5.2.1 The skin plate and stiffeners shall be designed together in composite manner.

Table 1 Materials for the Components of Fixed-Wheel Gates
(Clause 4)

| Sl No. | Component Part | Recommended Materials | Ref to, IS No. |
|--------|--|---|--|
| i) | Wheel | Cast steel | 1030 : 1998 |
| | | Cast iron | 210 : 1993 |
| | | Wrought steel | |
| | | Forged steel | 2004 : 1991 |
| ii) | Bearing/Bushing | Anti-friction bearing/bronze, phosphor bronze, aluminium bronze, self lubricating bushing of high strength brass-castings | 318 : 1981 305 : 1981 |
| iii) | Wheel pins or axles | Chrome nickel steel or corrosion resistance steel, mild steel with nickel or hard chromium plating | 2004 : 1991 2062 : 1999 1068 : 1993 1337 : 1993 |
| iv) | Structural parts of gate leaf, track base, etc | Carbon steel, structural steel | 1875 : 1992 2062 : 1999 8500 : 1991 |
| v) | Seal | Rubber | 11855 : 1986 |
| vi) | Wheel track | a) Stainless steel b) Corrosion resistance steel | 1570 (Part 5) : 1985 |
| vii) | Seal seat | Stainless steel plate | 1570 (Part 5) : 1985 |
| viii) | Seal base, seal seat base, sill beam | Structural steel of convenient shape | 2062 : 1999 8500 : 1991 |
| ix) | Seal clamp | Structural steel | 2062 : 1999 8500 : 1991 6603 : 2001 |
| | | Stainless steel | |
| x) | Guide | Structural steel or corrosion resistance steel or stainless steel | 2062 : 1999 8500 : 1991 6603 : 2001 |
| xi) | Springs | Spring steel Stainless steel | 6527 : 1995 2062 : 1999 |
| xii) | Anchor bolts | Structural steel | 6527 : 1995 |
| xiii) | Guide rollers and guide shoes | Structural steel or corrosion resistance steel, cast iron, cast steel or forged steel | 2062 : 1999 8500 : 1991 210 : 1993 1030 : 1998 2004 : 1991 |

NOTES

- 1 Grade of the material conforming to the specifications mentioned above shall be specified by the designer to suit to the particular requirement.
- 2 Cast iron shall not be used for wheels and tracks for high head gates.
- 3 The choice of material is governed by the type of installation, accessibility for maintenance, reservoir water properties, silt, etc.

5.2.2 The skin plate shall be designed for either of the following two conditions unless more precise methods are available:

- a) In bending across the stiffeners or horizontal girders as applicable; or
- b) As panels in accordance with the procedure and support conditions as given in Annex C.

5.2.3 The stresses in skin plates for conditions in 5.2.2 shall be determined as follows:

- a) For determining the stresses for conditions in bending across stiffeners or horizontal girders in accordance with the procedure given in 5.2.2 (a), bending moment shall be determined according to the conditions of supports.

- b) For calculating the stresses in skin plates for conditions in bending as panel in accordance with the procedure given in 5.2.2 (b), the stresses as given in Annex C shall be used.

5.2.4 In either of the cases specified in 5.2.2 while designing the stiffeners and horizontal girders the skin plate can be considered coacting with them.

- a) The coacting width of the skin plate in non-panel fabrication is as per 5.2.2 (a) shall be taken by restricting to the least of the following values:

- i) $40 t + B$

where

- t = thickness of skin plate, and
 B = width of stiffener flange in contact with the skin plate.

- ii) 0.11 span; and
 - iii) Centre-to-centre of stiffeners and girders.
- b) When skin plate coacts with girders as well as stiffeners to form a panel construction, width of skin plate coacting with horizontal girder or stiffener shall be as illustrated in Annex D.

5.2.5 The stresses so computed shall be combined in accordance with the formula:

$$\sigma_v = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3\tau_{xy}^2}$$

where

- σ_v = combined stress,
- σ_x = sum of stresses along x-axis,
- σ_y = sum of stresses along y-axis, and
- τ_{xy} = sum of shear stresses in x-y plane.

NOTE — The appropriate sign should be taken for σ_x σ_y in the above formulae.

5.2.6 The permissible values of mono-axial as well as combined stresses shall not be greater than those specified in Annex B.

5.2.6.1 Permissible values of stress in welds shall be the same as permitted for the parent material. For site weld the efficiency should be considered 80 percent of shop weld.

5.2.7 To take care of corrosion, the actual thickness of skin plate to be provided shall be at least 1.5 mm more than the theoretical thickness computed based on the stresses specified in Annex B. The minimum thickness of the skin plate shall not be less than 8 mm inclusive of corrosion allowance.

5.2.8 The stiffeners may if necessary be of a built-up section or of standard rolled section, that is, tees, angles, channels, etc.

5.3 Horizontal and Vertical Stiffeners and Main Girders

5.3.1 The horizontal and vertical stiffeners shall be designed as simply supported or continuous beam depending upon the framing adopted for gate. The spacing between main horizontal girders shall preferably be such that all the girders carry almost equal loads.

5.3.2 The end vertical girders shall be designed as continuous beams resting on wheel centre points with concentrated loads, coming from horizontal girders, at points where they meet the end vertical girders. Care shall be taken in carrying out the analysis of end girders to include torsional effects, if any.

5.3.3 The permissible values of stresses shall not be greater than those specified in Annex B.

5.3.4 Whenever the gate is connected to the hoisting mechanism at points other than the end vertical girders, care shall be taken to avoid stress concentration particularly on the web of the top horizontal girder. The hoisting force should preferably be dispersed through suitable stiffeners to one or more horizontal girders below the top one. The extra stresses arising due to this arrangement may be combined with other stresses to ensure that the permissible limits are not exceeded.

5.3.5 Deflection of Gates

Maximum deflection of the gate under normal conditions of loading shall be limited to 1/800 of the span (centre-to-centre of the wheels).

However, in case of gates with upstream top seals a maximum deflection of the gate leaf at the top seal shall not be more than 80 percent of the initial interference of the seal.

5.4 Wheels and Wheel Tracks

5.4.1 The gate wheels shall be suitable to withstand the stresses developed due to hydrostatic loads, which they will carry. Wheels may preferably be without flanges but may be flanged, where considered necessary. For high head and large spillway gates, the tread of the wheel or track may be slightly crowned to accommodate gate deflection under heavy load. The tread of the wheel may be flat when self-aligning bearings are used between the wheel and wheel pin.

5.4.1.1 The wheels shall be machined true to size and shall operate smoothly without vibration and without under going undue drift.

5.4.2 Design of Wheels with Point Contact

The capacity of the wheels shall be calculated in accordance with Annex E. A typical solved example is also given in Annex E. The maximum shear stress in N/mm² thus computed shall not exceed 2.41 X BHN where BHN is the Brinell Hardness Number of wheel tread or wheel path whichever is smaller, or 0.7 X ultimate tensile strength, whichever is less. In general, the required tread hardness shall penetrate to at least twice the depth at which the maximum shear stress occurs as calculated using the above curves. The tread width/track width shall be such that with the gate deflected under the actual design loads, the distance from the edge of the wheel tread/track shall be at least 15 mm. The radius of crowning of the wheel or track shall not be more than 10 times the radius of the wheel.

5.4.2.1 Permissible value of contact stress shall be taken as given against 'Point contact' in Annex F.

5.4.3 Design of Wheels with Line Contact

The contact stresses between the wheel and the track shall be calculated in accordance with the following formula:

$$f_c = 0.418 \sqrt{\frac{PE}{rl}}$$

where

- f_c = contact stress in N/mm²;
- P = wheel load, in N;
- E = modulus of elasticity, in N/mm²;
- r = radius of wheel, in mm; and
- l = tread width, in mm.

5.4.3.1 The permissible contact stress shall be as specified against 'line contact' in Annex F.

5.4.4 Wheel Pins

The wheels shall be mounted on fixed pins. The pin shall be harder than bronze bushing. Grease fittings shall be provided to permit greasing of the bearings at easily accessible location and suitable grease holes shall be provided in the pin for this purpose.

5.4.4.1 The wheel pin shall either be supported at both ends, on one side of the web of the vertical girder and on the other side by the stiffener plate or of cantilever box of the end vertical girder. In the latter case the rigidity of cantilever box should be ensured.

5.4.4.2 The wheel pin shall be designed for bearing, bending and shear; the load shall be taken as the wheel load acting on the width of the bearing. The pin supports shall be suitably stiffened against bearings and tearing. The permissible stresses shall be in accordance with stresses given in Annex B.

5.4.4.3 The pins may be given suitable eccentricity to permit alignment of wheels. Normal eccentricity provided is 5 mm.

5.4.5 Wheel Bearing

The wheel bearing may be bronze bushing, self-lubricating bushing or antifriction roller bearings of any suitable design to suit the operational requirements and installation of gates. Where bronze bushing is used, the bearing stress shall not exceed the values specified in Annex B.

5.4.5.1 For antifriction roller bearings the outer diameter of the roller bearing shall not exceed 0.6 times the wheel diameter in case of point contact and 0.8 times the wheel diameter in case of line contact. The bearing shall be selected on the basis of factor of safety of 1.5 on the static capacity.

5.4.5.2 The following formula shall be used for computing the wheel frictional forces for bush and roller bearing:

$$F = \frac{P}{R} (f_a \times r + f_r)$$

where

- F = total wheel friction, in N;
- P = total hydro-static load, in N;
- R = wheel radius, in mm;
- f_a = coefficient of axle friction (sliding);
- f_r = coefficient of rolling friction, in mm; and
- r = effective radius of bearing in mm.

a) *Coefficient of axle friction (sliding)* — The following values shall be used:

| For | Starting | Running |
|----------------|----------|---------|
| Bronze bushing | 0.20 | 0.15 |
| Roller bearing | 0.015 | 0.01 |

b) *Coefficient of rolling friction* — For rolling between wheel and wheel track, the coefficient of friction shall be taken as 1.0.

5.4.5.3 Fits and tolerances

When bronze bushing is provided, the bushing shall be force-fit in the wheel and the wheel pin shall be running-fit in the bushing. When roller bearing is provided, the outside diameter of bearing shall be tight-fit in the wheel and the pin shall be tight-fit in the inside diameter of bearing.

5.5 Seals and Accessories

5.5.1 Seals shall be fixed by means of seal clamps and G.I. or stainless steel bolts/stainless steel screws so as to ensure a positive water pressure between the seal and the gate, and to bear tightly on the seal seat to prevent leakage. For reducing the seal friction fluorocarbon clad seals may be used. Edges of seal clamp adjacent to seal bulb shall be rounded.

5.5.2 Various types of seals recommended for different classes for gates are given in Annex G for information.

5.5.2.1 For regulating gates, the designer at his discretion may make the seals effective throughout the range of the travel of gates either by fixing the seals to the embedded parts or by providing a liner plate above in continuation of the top seal seats for the entire width of the gate and range of regulation.

5.5.3 Initial Interference

The seal interference of double stem or music note type seal shall vary from 2 mm to 5 mm depending upon the requirement and type of installation at the discretion of the designer. The projection of bottom wedge seal

shall vary from 2 mm to 5 mm depending upon the requirement and type of installation at the discretion of the designer. The projection of bottom wedge seal shall vary from 2 mm to 5 mm depending upon the requirement and type of installation at the discretion of the designer. Suitable chamfer shall be provided at the bottom of the skin plate and clamp plate to accommodate the bottom wedge seal in compressed position (see IS 11855).

5.5.4 Seal Friction

For the purpose of calculating the frictional forces to overcome, the following friction coefficients shall be used:

| For | Starting | Moving |
|---------------------------------|----------|--------|
| Rubber seal on stainless steel | 1.50 | 1.20 |
| Fluorocarbon on stainless steel | 0.20 | 0.15 |

5.6 Guide Rollers and Guide Shoes

5.6.1 Gate guide roller/shoes shall be provided on the sides of the gates to limit the lateral motion of gate to not more than 6 mm in either direction. The rollers shall be flanged and travel on steel plates or rails securely attached to anchor bolts. In case of rollers it shall be provided with bronze bushing or self lubricating bushing turning on fixed steel pins. Suitable arrangement for lubrication of these rollers shall also be provided. Where necessary, counter guide rollers shall be provided to limit the transverse movement of gates.

5.6.2 A minimum of two guide rollers or shoes should be provided on each side of the gate to resist the transverse and lateral movement of the gate and at same time to prevent the gate from jamming. A clearance of 3 mm to 6 mm between the guide rollers and guide surface is normally recommended. The guide rollers or shoes should be structurally adequate to withstand the load, they are likely to be subjected to, depending upon the type of installation, hoist and hydraulic condition. Guide rollers may also be provided with suitable springs, whenever required. Guide rollers may be preferred for high head gates and gates to be handled by lifting beams.

5.6.3 Suitable spring assembly may be provided beneath the guide shoes or guide roller assembly to restore the gate to normal position after any deflection, specially for high head gates.

5.6.4 The guide roller/shoes shall be designed to the maximum loads to which they may be subjected during operation. A minimum load of 5 percent of the total dead weight of the gate is recommended for the design of each guide roller.

5.7 Wheel Track and Track Base

5.7.1 The wheel track shall provide a true and smooth machined surface for the wheels to roll and transmit the loads through the wheels to the track base.

5.7.2 The hardness of wheel track surface shall be kept minimum 50 points Brinell Hardness Number (BHN) higher than that of the wheel tread to reduce wear. For gates which may not be put to frequent use, the difference between the BHN of wheel and wheel track may be reduced suitably at the discretion of the designer.

5.7.3 Thickness of Track Plate (Wheel Track with Line Contact)

The thickness of track plate shall be calculated from the following formula:

$$b = 1.55 \sqrt{\frac{P}{l} \times \frac{r}{E}}$$

where

- l = tread width, in mm;
- b = half contact width, in mm;
- P = wheel load, in N;
- r = radius of wheel, in mm; and
- E = modulus of elasticity, in N/mm².
- Z_1 = depth to the point of maximum shearing stress, in mm
- = 0.786 b .

5.7.3.1 The thickness of the wheel track shall not be less than 6 times the depth to the point of maximum shearing stress (Z_1) as calculated in 5.7.3.

5.7.4 Thickness of Track Plate (Wheel Track with Point Contact)

The thickness of track plate shall be calculated by the following formula:

$$t = \frac{1.27 P}{2c \times f_t}$$

where

- t = rack thickness, in mm;
- P = wheel load, in N;
- $2c$ = track width, in mm; and
- f_t = allowable track bending stress, in N/mm² (0.4 YP of track material).

NOTE — The minimum thickness of track plate shall be 10 mm.

5.7.5 The track base shall be embedded in concrete. It shall be designed as a beam on elastic foundation. The stresses in concrete under the track shall be found from

the following formula. The stress in bearing for concrete shall not exceed the values specified in IS 456. Second stage concrete shall be of at least M 20 grade.

$$p = 0.281 \ 3 \times P \left(\frac{E_c}{E_s \times I \times w^2} \right)^{1/3}$$

where

- p = bearing stress in concrete, in N/mm²;
 P = total wheel load, in N;
 E_c = modulus of elasticity of concrete, in N/mm²;
 E_s = modulus of elasticity of steel, in N/mm²;
 I = moment of inertia of track base, in mm⁴; and
 w = width of track base in contact with concrete, in mm.

5.7.5.1 The edge distance of the bearing flange of track base from the groove face shall be determined on the basis of the following criteria:

- a) The wider flange, in case of double flanged track base, shall be considered as bearing

flange for the purpose of transferring load from the track base to the concrete.

- b) The minimum edge distance 'e' of the bearing plate flange shall in no case be less than 150 mm.
c) The load shall be assumed to be distributed at 45° dispersion as shown in Fig. 2.
d) The width of loaded area at the interface of primary and secondary concrete shall fully lie in the primary concrete. Clear cover of the reinforcement is to be neglected as shown in Fig. 2.

5.7.5.2 The length of influence of the parabolic distribution under the track base may be found from the following formula:

$$L = \frac{3}{2} \times \frac{P}{w \times p}$$

where

- L = length of influence under track base in mm,
 P = total wheel load in N,

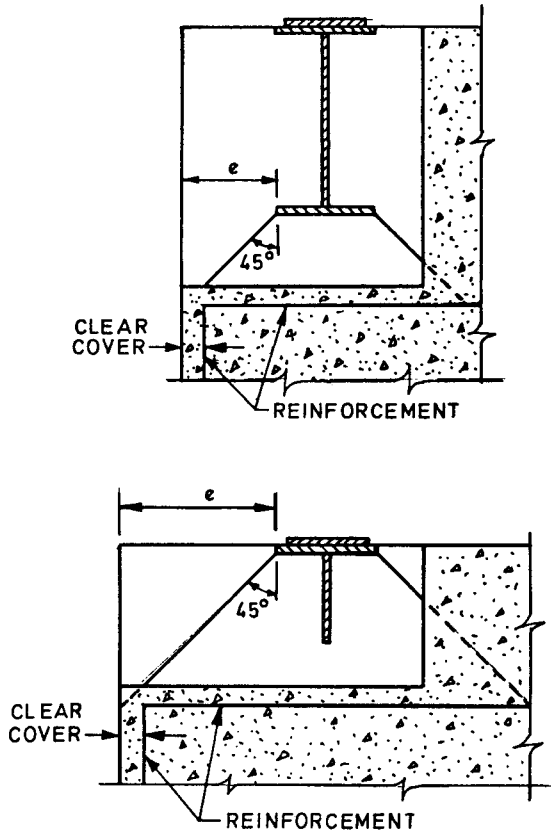


FIG. 2 EDGE DISTANCE CRITERIA FOR TRACK BASE

w = width of track in contact with concrete in mm, and

p = stress in concrete in N/mm².

5.7.5.3 If pressure distribution under adjacent wheels overlaps, superposition of the pressures shall be adopted and checked for the worst condition.

5.7.5.4 The track base shall be checked for bending and shear also. Bending stress shall be calculated from the following formula:

$$\sigma_b = 0.5 \frac{P}{Z} \left(\frac{E_s}{E_c} \times \frac{I}{w} \right)^{1/3}$$

where

σ_b = bending stress, in N/mm²;

P = load on roller, in N;

Z = modulus of section of the track base about the neutral axis, in mm³;

E_c = modulus of elasticity of concrete, in N/mm²;

E_s = modulus of elasticity of steel, in N/mm²;

I = moment of inertia of the track base about the neutral axis, in mm⁴; and

w = width of track base in contact with concrete, in mm.

5.7.5.5 The flange of the track base shall be checked for bending. The web of the track base shall also be checked for compression. Permissible stress in compression for web shall be taken as 85 percent of yield point for normal condition and equal to yield point for MWL/occasional load condition.

5.7.6 The permissible stresses in track base shall be those as specified in Annex B.

5.8 Guides

5.8.1 The guides shall be fixed inside the groove in piers.

5.8.2 The guide shall be flat plate or a rail section anchored into concrete for gates fixed with guide rollers. The thickness of the plate shall not be less than as given below:

| Type of Gate | Thickness of Plate, mm |
|------------------|---------------------------|
| Low head gate | 20 |
| Medium head gate | 32 |
| High head gate | 40 |

5.8.3 The guide shall be suitable for the type of guide rollers or shoes provided on the gate.

5.8.4 The guides shall continue to the full range of travel of the gate.

5.9 Seal Seat, Seal Seat Base, Seal Base and Sill Beam

5.9.1 The minimum width of seal seat shall be 80 mm excluding the required chamfer.

5.9.2 The minimum thickness of the stainless steel plates for low head gates may be adopted as 6 mm and for medium and high head gates to 8 mm.

5.9.3 The seal seat shall be welded or screwed with corrosion resisting steel screws to the seal seat base. The number of screws shall be sufficient for rigidity of the seat on base and water tightness.

5.9.4 The seal seat shall be finished smooth to present a smooth surface to the gate seal.

5.9.5 The seal seat base shall be embedded in concrete.

5.9.6 The edges of side and top seal seat shall be rounded/chamfered (see Fig. 3) to prevent damage to rubber seal during gate operation.

5.9.7 The sill beam, may be provided, with the corrosion resistant steel flats welded or screwed with corrosion resistant steel screws. The surface of the sill beam may be machined smooth, wherever required, and made flush with the surrounding concrete.

5.10 Ballast

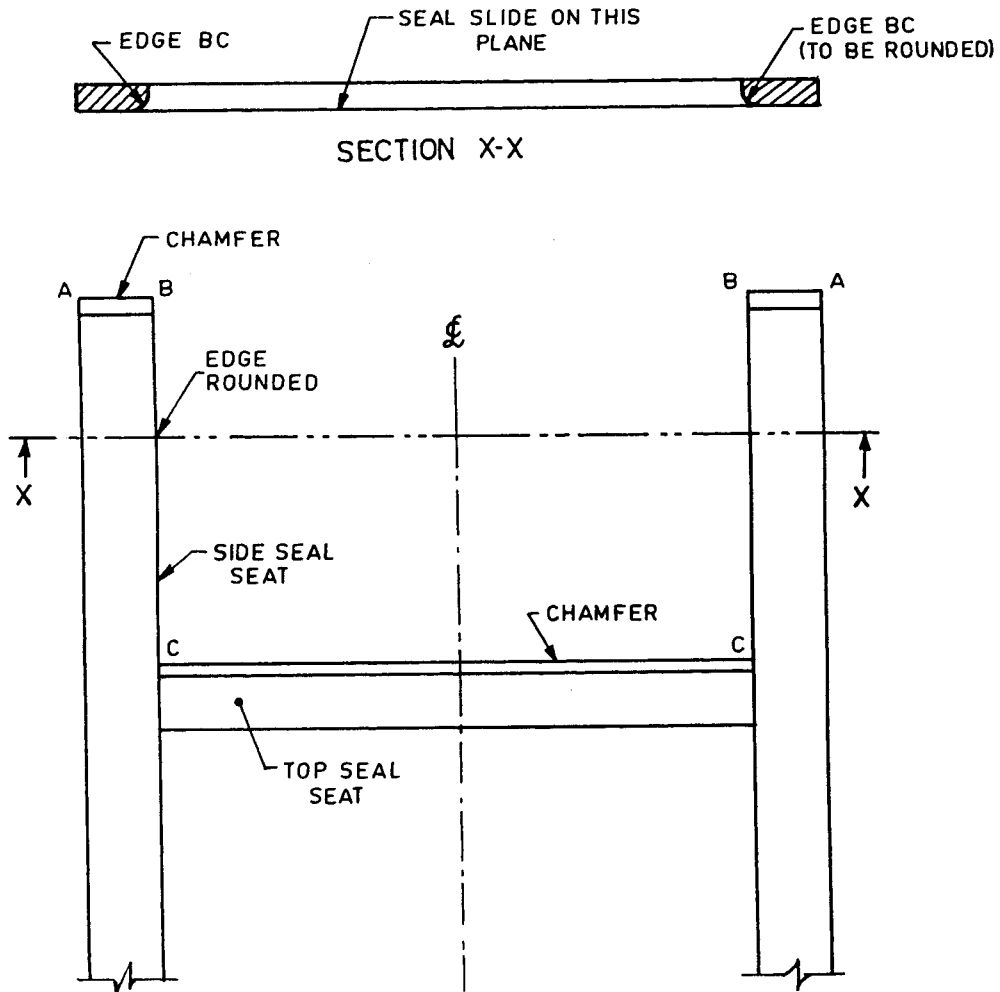
5.10.1 Suitable ballast in the form of dead weight shall be added for making the gate self-closing, when necessary. The ballast shall be in the form of cast iron/pig iron billets, concrete or any other suitable material and shall be secured firmly in between the webs of the horizontal girders. Precaution shall be taken to ensure that the ballast is not dislodged from its position during the gate operation.

5.10.2 The effect of dead weight of the ballast on the horizontal girders shall be analyzed.

5.10.3 The centre of gravity of the gate shall be determined after the consideration of the location of the ballast.

5.11 Anchorage or Anchor Plates

5.11.1 Anchorages shall be provided in the first stage concrete, with suitable blockout openings, to hold the embedded parts of the second stage concrete. The anchor bolts in the second stage concrete shall be with double nuts and washers. For adjustment purposes enlarged holes in the embedded parts of the second stage concrete shall be provided. Preferably the anchor plates may be embedded with first stage concrete and anchor bolts welded subsequently. The minimum size (diameter) of anchor bolts shall not be less than 16 mm and the anchor plate thickness shall not be less than 8 mm.



NOTES

- 1 Edges AB and CC to be chamfered.
- 2 Edges BC to BE rounded.

FIG. 3 ROUNDING/CHAMFERING ON SEAL SEAT

5.12 Tolerances

The tolerances for embedded parts and in components of gate shall be as given in Annex H.

6 EARTHQUAKE EFFECT

6.1 Where the project lies in a seismic zone earthquake forces shall be considered in accordance with IS 1893, and the gate designed accordingly.

6.2 The allowable stresses as given in Annex B shall be increased $33\frac{1}{3}$ percent in case of earthquake conditions subject to an upper limit of 85 percent of the yield point. In case of nuts and bolts increase in stress shall not be more than 25 percent of allowable stress.

6.2.1 The permissible values of stresses in welded connections shall be the same as permitted for parent material.

7 WAVE EFFECT

7.1 For very wide and big reservoirs, the effect of wave height due to storms, etc, in causing increased loading on the gate, shall also be considered.

7.2 Increased stresses in various parts of the gate, as described in 6.2 for earthquake forces, shall be allowed for the wave effect.

7.3 The earthquake forces and the wave effect shall not be considered to act together while computing the increased stresses in the gate.

8 ICE LOADS

8.1 Ice Impact and Ice Pressure

Provided local conditions do not impose other values, ice impact and ice pressure shall be taken into account in such a way that the water pressure triangle shall be replaced as given below:

- a) In waters with ice thickness greater than 300 mm, by an even surface pressure of 30 000 N/mm² up to 3 m depth; and

- b) In waters with ice thickness up to 300 mm, by an even surface of 20 000 N/mm² up to 2 m depth.

9 MWL CONDITION

In case the gate is to be checked for MWL condition, the allowable stress shall be increased by $33\frac{1}{3}$ percent of the values specified in Annex B subject to the upper limit of yield point. However, if the gates are required to be designed for MWL condition, normal stresses shall be taken in accordance with Annex C.

ANNEX A

(Clause 2)

LIST OF REFERRED INDIAN STANDARDS

| IS No. | Title | IS No. | Title |
|----------------------|---|--------------|---|
| 210 : 1993 | Grey iron castings — Specification (<i>fourth revision</i>) | 1875 : 1992 | Carbon steel billets, blooms, slabs and bars for forgings (<i>fifth revision</i>) |
| 305 : 1981 | Aluminium bronze ingots and castings (<i>second revision</i>) | 1893 : 1984 | Criteria for earthquake resistant design of structures (<i>fourth revision</i>) |
| 318 : 1981 | Leaded tin bronze ingots and castings (<i>second revision</i>) | 2004 : 1991 | Carbon steel forgings for general engineering purposes (<i>third revision</i>) |
| 1030 : 1998 | Carbon steel castings for general engineering purposes (<i>fifth revision</i>) | 2062 : 1999 | Steel for general structural purposes — Specification (<i>fifth revision</i>) |
| 1068 : 1993 | Electroplated coatings of nickel plus chromium and copper plus nickel plus chromium (<i>third revision</i>) | 6527 : 1995 | Stainless steel wire rod (<i>first revision</i>) |
| 1337 : 1993 | Electroplated coatings of hard chromium on iron and steel for engineering purposes (<i>third revision</i>) | 6603 : 1972 | Stainless steel bars and flats — Specification (<i>first revision</i>) |
| 1570 (Part 5) : 1985 | Schedules for wrought steels: Part 5 Stainless and heat resisting steels (<i>second revision</i>) | 8500 : 1991 | Structural steel — Micro alloyed (medium and high strength qualities) (<i>first revision</i>) |
| | | 11855 : 1986 | General requirements for rubber seals for hydraulic gates |

ANNEX B

(Clauses 5.2.6, 5.2.7, 5.3.3, 5.4.4.2, 5.4.5, 5.7.6, 6.2 and 9)

PERMISSIBLE MONOAXIAL STRESSES FOR STRUCTURAL COMPONENTS OF HYDRAULIC GATES

| Sl No. | Material and Type | Wet Condition | | Dry Condition | |
|----------------------|--------------------------------|-----------------|-----------------|-----------------|-----------------|
| | | Accessible | Inaccessible | Accessible | Inaccessible |
| (1) | (2) | (3) | (4) | (5) | (6) |
| a) Structural steel: | | | | | |
| i) | Direct compression | 0.45 γ_P | 0.40 γ_P | 0.55 γ_P | 0.45 γ_P |
| ii) | Compression/Tension in bending | 0.45 γ_P | 0.40 γ_P | 0.55 γ_P | 0.45 γ_P |
| iii) | Direct tension | 0.45 γ_P | 0.40 γ_P | 0.55 γ_P | 0.45 γ_P |
| iv) | Shear stress | 0.35 γ_P | 0.30 γ_P | 0.40 γ_P | 0.35 γ_P |
| v) | Combined stress | 0.60 γ_P | 0.50 γ_P | 0.75 γ_P | 0.60 γ_P |
| vi) | Bearing stress | 0.65 γ_P | 0.45 γ_P | 0.75 γ_P | 0.65 γ_P |
| b) Bronze or Brass: | | | | | |
| | Bearing stress | 0.035 UTS | 0.030 UTS | 0.040 UTS | 0.035 UTS |

NOTES

- 1 γ_P stands for minimum guaranteed yield point stress. UTS stands for ultimate tensile strength. For materials which have no definite yield point, the yield point may be taken at 0.2 percent proof stress.
- 2 When the members are subjected to direct compression/compression in bending, the l/r ratio of members is to be considered and the stresses correspondingly reduced in proportion given in Annex B and shall be in accordance with IS 800 : 1984.
- 3 The term 'wet condition' applies to skin plates and those, etc, on down stream side components of gate which may have a sustained contact with water, for example, horizontal girder and other components located on up stream side of skin plate. The term 'dry condition' applies to all components which generally do not have a sustained contact with water, for example, girders, stiffeners of skin plate, even though there may be likelihood of their wetting due to occasional spray of water. Stop logs are stored above water level and are only occasionally used. Hence, stresses given under dry and accessible conditions should be applied to them in accordance with 5.2.7.
- 4 The term 'accessible' applies to gates which are kept in easily accessible locations and can, therefore, be frequently inspected and maintained, for example, gates and stoplogs which are stored above water level and are lowered only during operations. The term 'inaccessible' applies to gates which are kept below water level and/or are not easily available for frequent inspection and maintenance. For example, gates kept below water level or in the bonnet space even while in the raised position or gates which on account of their frequent use are generally in water.

ANNEX C

[Clauses 5.2.2(b), 5.2.3(b) and 9]

METHOD OF COMPUTATION OF BENDING STRESS IN FLAT PLATES

C-1 STRESS OF FLAT PLATES IN PANELS

Bending stress in flat plates may be computed from the following formula:

$$\sigma = \frac{K}{100} \times \frac{p \times a^2}{s^2}$$

where

σ = bending stress in flat plate, in N/mm²;

K = non-dimensional factor depending on values of a and b ;

p = water pressure (relative to the plate centre), in N/mm²;

a, b = bay width as in Fig. 4 to 9, in mm; and

s = plate thickness, in mm.

The values of K for the points and support conditions given in Fig. 4 to 9 are given in Tables 2, 3 and 4.

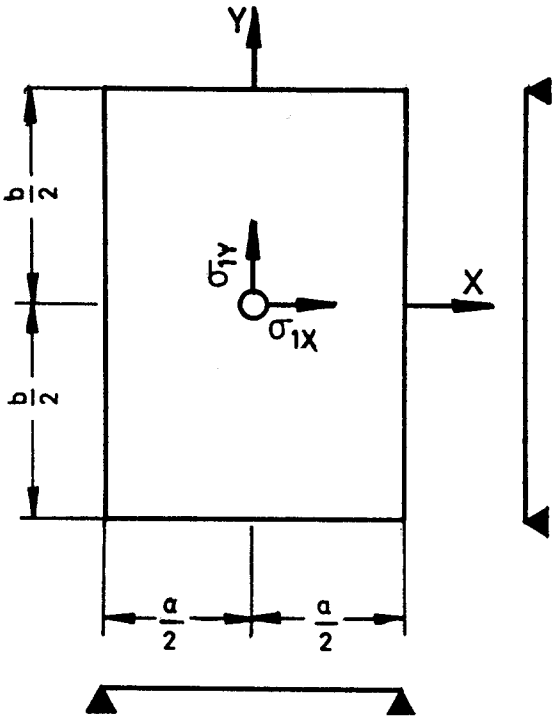


FIG. 4 ALL EDGES SIMPLY SUPPORTED

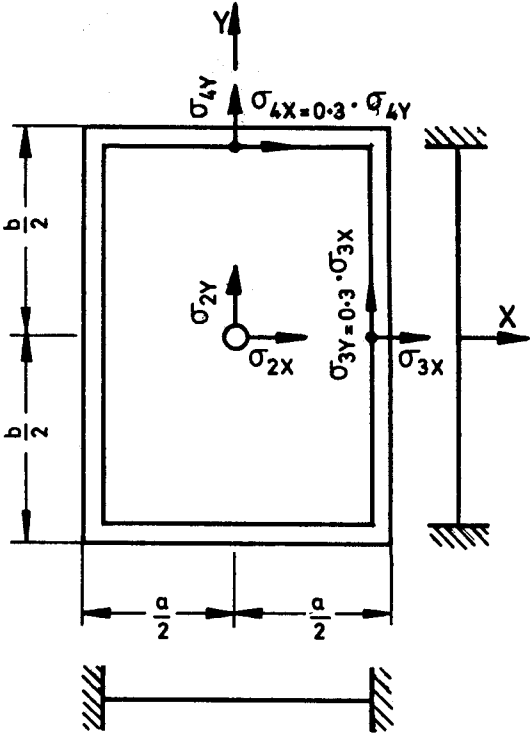


FIG. 5 ALL EDGES RIGIDLY FIXED

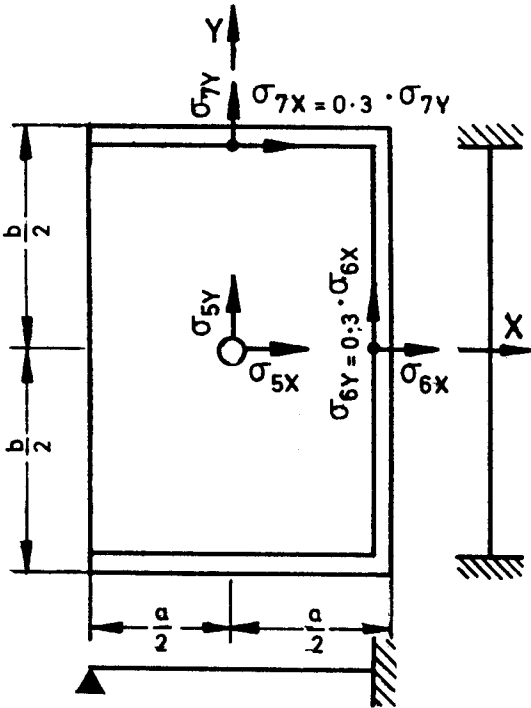


FIG. 6 TWO SHORT AND ONE LONG EDGES FIXED AND ONE LONG EDGE SIMPLY SUPPORTED

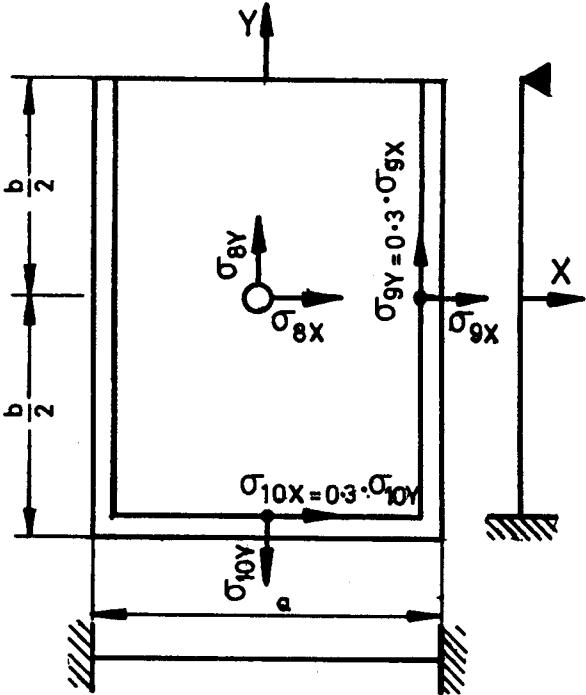


FIG. 7 TWO LONG AND ONE SHORT EDGES FIXED AND ONE SHORT EDGE SIMPLY SUPPORTED

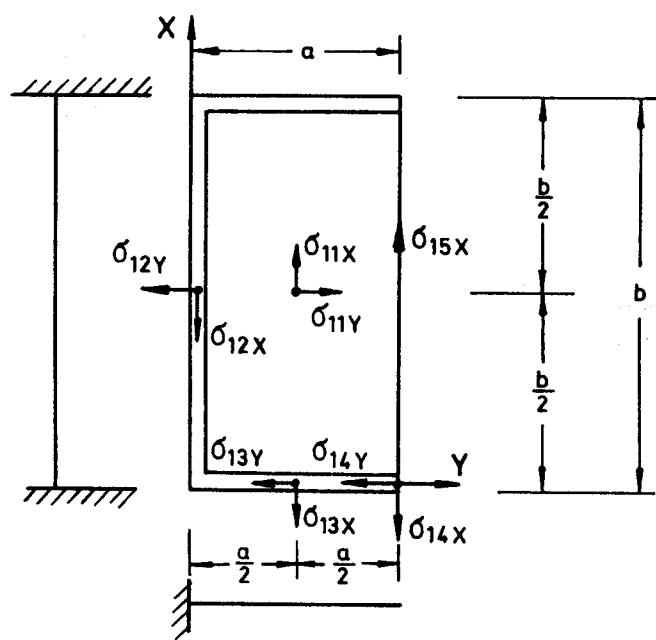


FIG. 8 THREE EDGES FIXED AND ONE (LONGER) EDGE FREE

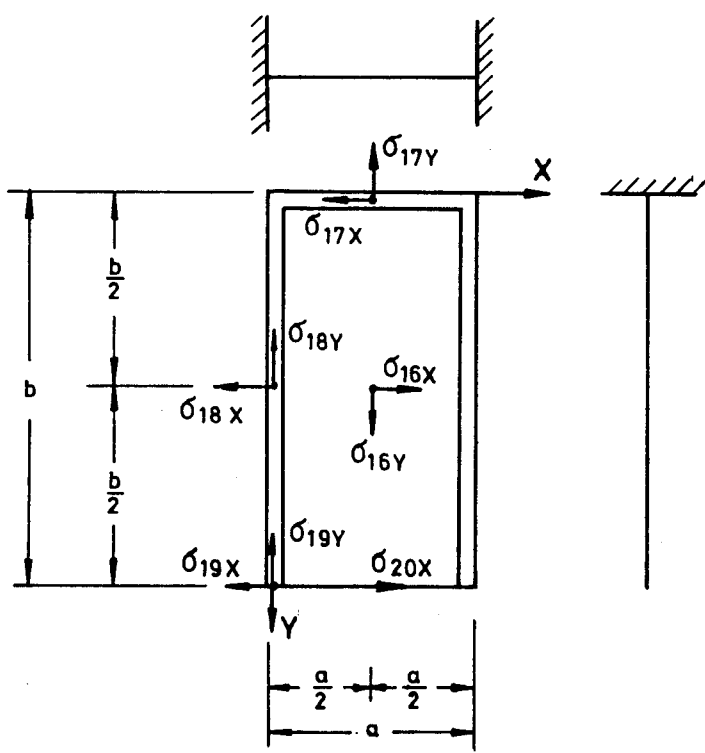


FIG. 9 THREE EDGES FIXED AND ONE (SHORTER) EDGE FREE

Table 2 Values of K for Points and Support Conditions given in Fig. 4 to 7
(Clause C-1)

| $\frac{b}{a}$ | $\pm \sigma_{1x}$ | $\pm \sigma_{1y}$ | $\pm \sigma_{2x}$ | $\pm \sigma_{2y}$ | $\pm \sigma_{4y}$ | $\pm \sigma_{3x}$ | $\pm \sigma_{5x}$ | $\pm \sigma_{5y}$ | $\pm \sigma_{7y}$ | $\pm \sigma_{6x}$ | $\pm \sigma_{8x}$ | $\pm \sigma_{8y}$ | $\pm \sigma_{10y}$ | $\pm \sigma_{9x}$ |
|---------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|-------------------|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| α | 75 | 22.5 | 25 | 7.5 | 34.3 | 50 | 37.5 | 11.3 | 47.2 | 75 | 25 | 7.5 | 34.2 | 50 |
| 3 | 71.3 | 24.4 | 25 | 7.5 | 34.3 | 50 | 37.4 | 12.0 | 47.1 | 74.0 | 25 | 7.6 | 34.2 | 50 |
| 2.5 | 67.7 | 25.8 | 25 | 8.0 | 34.3 | 50 | 36.6 | 13.3 | 47.0 | 73.2 | 25 | 8.0 | 34.2 | 50 |
| 2 | 61.0 | 27.8 | 24.7 | 9.5 | 34.3 | 49.9 | 33.8 | 15.5 | 47.0 | 68.3 | 25 | 9.0 | 34.2 | 50 |
| 1.75 | 55.8 | 28.9 | 23.9 | 10.8 | 34.3 | 48.4 | 30.8 | 16.5 | 46.5 | 63.2 | 24.6 | 10.1 | 34.1 | 48.9 |
| 1.5 | 48.7 | 29.9 | 22.1 | 12.2 | 34.3 | 45.5 | 27.1 | 18.1 | 45.5 | 56.5 | 23.2 | 11.4 | 34.1 | 47.3 |
| 1.25 | 39.6 | 30.1 | 18.8 | 13.5 | 33.9 | 40.3 | 21.4 | 18.4 | 42.5 | 47.2 | 20.8 | 12.9 | 34.1 | 44.8 |
| 1 | 28.7 | 28.7 | 13.7 | 13.7 | 30.9 | 30.9 | 14.2 | 16.6 | 36.0 | 32.8 | 16.6 | 14.2 | 32.8 | 36.0 |

NOTE — The edges over which the panels are continuous may, for all practical purposes, be treated as edges rigidly fixed. However, more exact analysis may be resorted to at the discretion of the designer.

Table 3 Values of K for Points and Support Conditions given in Fig. 8
(Clause C-1)

| Sl No. | $\frac{b}{a}$ | σ_{11x} | σ_{11y} | σ_{12x} | σ_{12y} | σ_{13x} | σ_{13y} | σ_{14x} | σ_{14y} | σ_{15x} | σ_{15y} |
|--------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| i) | α | 22.00 | 75.00 | 90.00 | 300.0 | 91.00 | 28.00 | 205.00 | 62.00 | 2.00 | 0 |
| ii) | 1.0 | 17.67 | 12.29 | 9.45 | 31.5 | 37.64 | 11.29 | 44.55 | 13.4 | 27.96 | 0 |
| iii) | 1.25 | 22.5 | 13.0 | 15.5 | 51.5 | 48.0 | 14.8 | 53.0 | 16.2 | 37.0 | 0 |
| iv) | 1.50 | 23.5 | 14.2 | 20.5 | 72.5 | 59.5 | 18.2 | 82.0 | 22.7 | 48.0 | 0 |
| v) | 1.75 | 23.0 | 14.0 | 25.8 | 87.0 | 67.5 | 20.8 | 112.0 | 34.8 | 61.0 | 0 |
| vi) | 2.0 | 19.49 | 6.72 | 33.98 | 113.28 | 72.96 | 21.89 | 134.4 | 40.32 | 69.88 | 0 |
| vii) | 2.5 | 18.37 | 2.88 | 42.05 | 140.16 | 51.84 | 15.55 | 124.8 | 37.44 | 52.42 | 0 |
| viii) | 3.0 | 19.78 | 7.68 | 44.93 | 149.76 | 65.28 | 19.59 | 109.44 | 32.84 | 52.41 | 0 |

Table 4 Values of K for Points and Support Conditions given in Fig. 9
(Clause C-1)

| Sl No. | $\frac{b}{a}$ | σ_{16x} | σ_{16y} | σ_{17x} | σ_{17y} | σ_{18x} | σ_{18y} | σ_{19x} | σ_{19y} | σ_{20x} | σ_{20y} |
|--------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| i) | α | 29.00 | 9.00 | 9.00 | 30.0 | 50.00 | 15.00 | 51.00 | 16.00 | 29.00 | 0 |
| ii) | 1.0 | 17.67 | 12.29 | 9.45 | 31.5 | 37.64 | 11.29 | 44.55 | 13.4 | 27.96 | 0 |
| iii) | 1.25 | 20.8 | 11.70 | 8.96 | 29.87 | 28.0 | 8.4 | 34.5 | 10.35 | 28.53 | 0 |
| iv) | 1.50 | 25.51 | 11.12 | 8.48 | 28.28 | 21.04 | 6.31 | 25.53 | 7.66 | 29.11 | 0 |
| v) | 1.75 | 26.48 | 10.56 | 8.49 | 28.3 | 32.0 | 9.6 | 36.5 | 10.95 | 28.97 | 0 |
| vi) | 2.0 | 27.46 | 10.0 | 8.5 | 28.36 | 45.52 | 13.66 | 50.09 | 15.27 | 28.81 | 0 |
| vii) | 2.5 | 28.07 | 9.13 | 8.51 | 28.38 | 46.66 | 14.0 | 50.8 | 15.24 | 28.78 | 0 |
| viii) | 3.0 | 28.18 | 8.68 | 8.51 | 28.38 | 46.94 | 14.08 | 50.81 | 15.24 | 28.77 | 0 |

ANNEX D

[Clause 5.2.4(b)]

METHOD OF CALCULATION OF COACTING WIDTH OF SKIN
PLATE WITH BEAM OR STIFFENERS

D-1 METHOD

D-1.1 Coacting width of skin plate is given by $2VB$:

where

- V = reduction factor (non-dimensional) depends on the ratio of the support length to the span of the plate and on the action of the moments, and is ascertainable from Fig. 10 and Fig. 11; and
- B = half the span of the plate between two girders (see Fig. 10) or overhang length of a bracket plate.

D-1.1.1 The ideal support length (L_I or L_{II} , see Fig. 10) corresponding to the length of the moment zone of equal sign shall in the case of continuous girders be basis with regard to support length L . In the case of single bay girders, the ideal support length corresponds to the actual:

- V_I = reduction factor corresponding to the parabolic moment zone (see Fig. 10 and 11), and
- V_{II} = reduction factor corresponding to the moment zone composed of two concave parabolic stresses and approximately the triangular shaped moment zone (shown with dashes in Fig. 10 and 11).

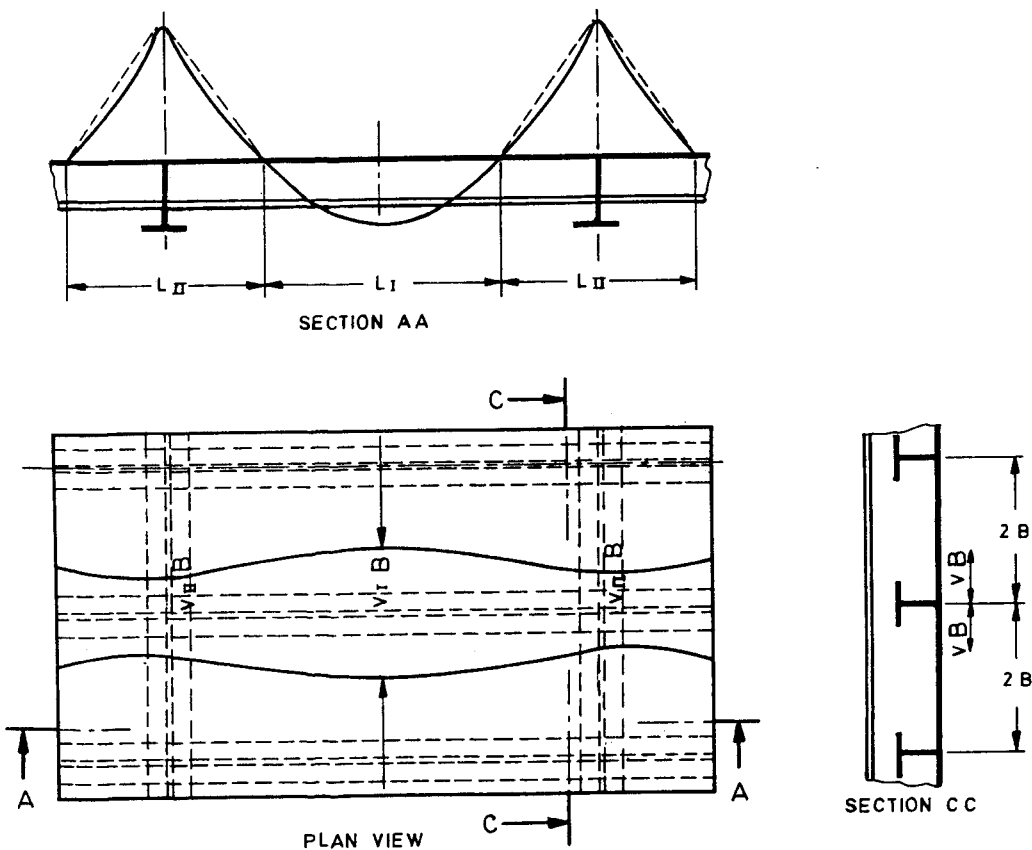


FIG. 10 FIGURE SHOWING VARIATION OF COACTING WIDTH FROM SUPPORT TO SUPPORT

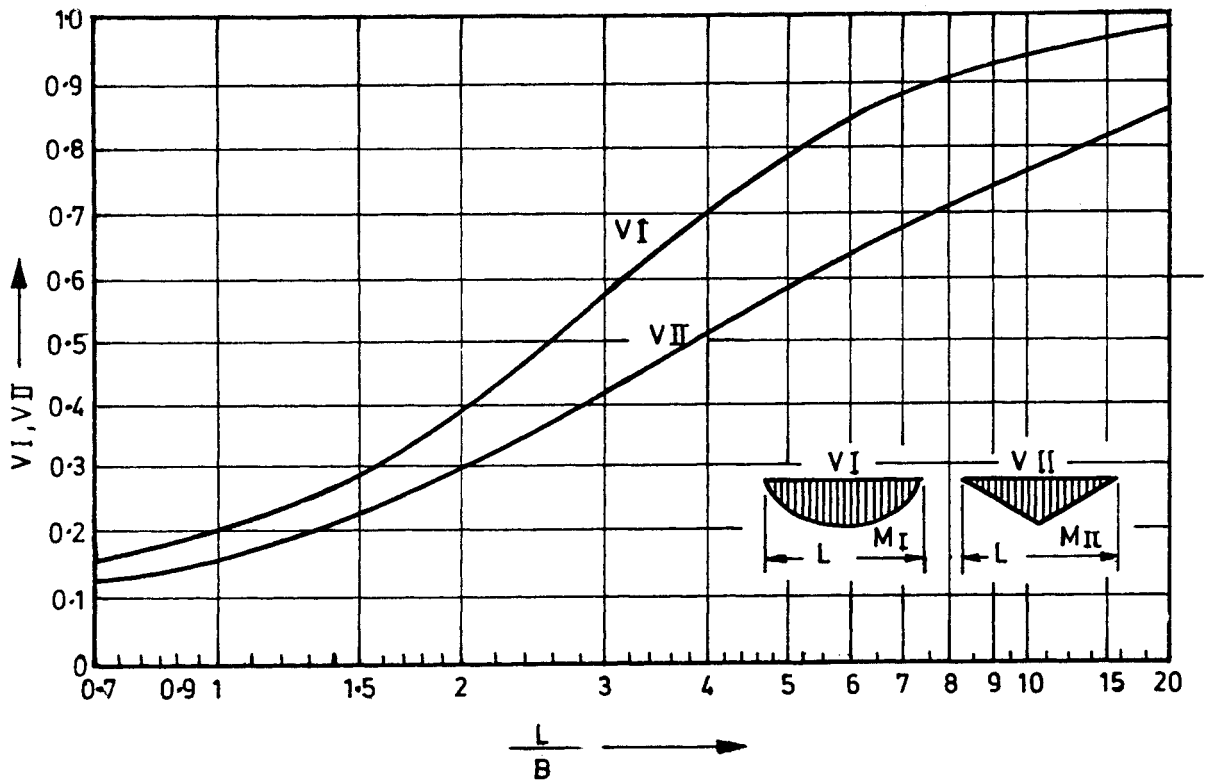


FIG. 11 CURVES SHOWING RELATIONSHIP BETWEEN $\frac{L}{B}$ AND REDUCTION FACTORS V_I AND V_{II}

ANNEX E

(Foreword, and Clause 5.4.2)

PROCEDURE FOR CALCULATION OF CAPACITY OF WHEEL FOR POINT CONTACT

E-1 PROCEDURE

E-1.1 Knowing the water load on the gate, the procedure for wheel design is as given in E-1.2 to E-1.5.

E-1.2 The design of the wheels is governed primarily by the stress in the tread. The required projected area of the tread, that is, the area represented by the product of wheel diameter and net tread-width, is determined by the following formula:

Critical stress of projected area in N/mm^2

$$= (\text{Brinell hardness number} \times 0.169) - 15.174$$

E-1.3 Owing to the necessarily extreme stiffness of the vertical girders of the gate on which the wheels

are mounted and to allow for slight misalignment of track surfaces, it is assumed that any wheel on one side of the gate may not bear on the track for a short distance of travel. This condition will cause an overload on some of the adjacent wheels which is taken for design, with a factor of safety of 2.0 over the critical stress on projected area while for a normal case, that is, all the wheels bearing evenly on the tracks, the factor of safety shall be taken as 3.0. The contact of all the rollers with the track can be ensured if the gate is designed as semi-flexible with a number of elements each fitted with only two wheels on either side. The vertical girder in such construction is discontinuous.

E-1.4 After diameter and net tread dimensions of wheel have been suitably chosen from the above formula, the stress may be analyzed with the help of Fig. 11 and formula given below:

Maximum shearing stress, in $\text{N/mm}^2 = 0.5 ({}_1Z_z - {}_1Y_y)$

Value of maximum difference of stress components (${}_1Z_z - {}_1Y_y$) can be calculated from the known values of variables

$$\frac{\Lambda}{a} ({}_1Z_z - {}_1Y_y), \frac{Z_1}{a}, \frac{Z_1 \Lambda P}{a^3}$$

which are read with Fig. 10 for known values of B/A where

B = mean of reciprocals of radii in y -direction
$$= \frac{1}{2R_2};$$

A = mean of reciprocals of radii in x -direction
$$= \frac{1}{2R_1};$$

$R_1^{1)}$ = radius of crowning of wheel, in mm;

R_2 = radius of wheel, in mm;

$\Lambda = \frac{2(1-\mu^2)}{E(A+B)}$ = evaluation of elastic property and shape property;

μ = poisson's ratio = $\frac{1}{4}$;

E = moduli of elasticity, in N/mm^2 ;

Z_1 = depth to point of maximum stress difference or point at which maximum shearing stress occurs in mm;

a = semi-major axis of ellipse of contact, in mm; and

P = wheel load, in N.

E-1.5 The horizontal compression between wheel and track for curved contact is given by:

$$P_{\text{Max}} = \frac{1.5 P}{\pi ab}$$

where

P_{Max} = maximum horizontal compressive stress, in N/mm^2 ;

P = wheel load, in N;

a = semi-major axis of ellipse of contact, in mm; and

b = semi-minor axis of ellipse of contact, in mm.

It may be noted that $b = K_a$ in which values of K can be read from Fig. 12.

¹⁾ The above will hold good for a flat track and a crowned wheel. In cases where a flat wheel with a crowned track is used, R_1 may be taken as the radius of track, in mm.

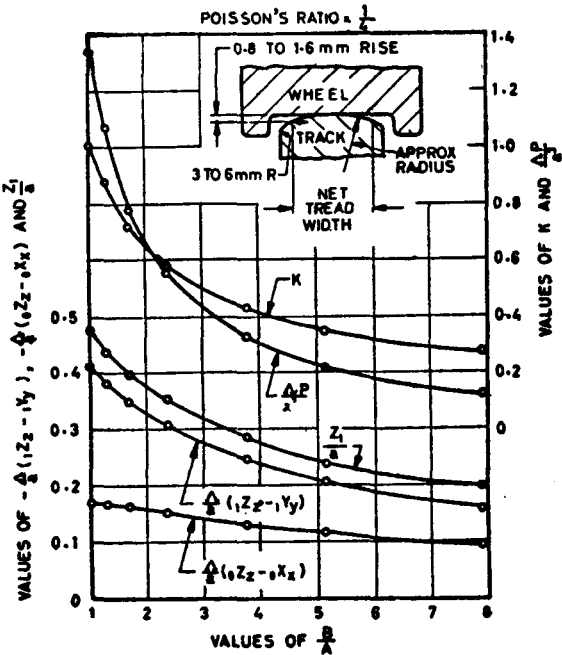


FIG. 12 CURVES FOR DETERMINATION OF STRESSES IN WHEELS

E-2 ILLUSTRATIVE EXAMPLE

E-2.1 Data

- a) Wheel load:
normal = 232 105 N
maximum = 356 495 N (say with one wheel not touching)
- b) Wheel = 430 mm *Max* (determined diameter from other practical considerations)
- c) Wheel material:
Steel with UTS
Rim hardened to BHN 255 = 883 N/mm^2

E-2.2 Design Procedure

- a) Critical stress = $(0.169 \times \text{BHN}) - 15.174$
(see E-1.2)
= $(0.169 \times 255) - 15.174$
= 27.921 N/mm^2 of the projected area
 - b) Allowable stress = $\frac{27.921}{3}$
= 9.307 N/mm^2 of projected area for normal load (factor of safety = 3)
- or
- $$= \frac{27.921}{2}$$

- = 13.96 N/mm² of projected area for maximum load (factor of safety = 2)
- c) Projected area required
- $$= \frac{232\ 105}{9.307}$$
- $$= 24\ 939\ \text{mm}^2 \text{ for normal load}$$
- or
- $$= \frac{356\ 495}{13.96}$$
- $$= 25.537\ \text{mm}^2 \text{ for maximum load}$$
- d) Net tread width required
- $$= \frac{25\ 537}{430}$$
- $$= 59.38\ \text{mm}$$
- Provide say 60 mm
- e) Check for maximum shear stress
- P = wheel load = 356 495 N
- R_1 = radius of wheel (assumed) crowning = 768 mm
- R_2 = radius of wheel = 215 mm
- μ = poisson's ratio = $\frac{1}{4} = 0.25$

$$\frac{B}{A} = \frac{1}{2R_2} - \frac{1}{2R_1} = \frac{R_1}{R_2}$$

$$= \frac{768}{215}$$

$$= 3.57$$

$$B + A = \frac{1}{2} \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$$

$$= \frac{1}{2} (0.001\ 30 + 0.004\ 65)$$

$$= 0.002\ 98$$

From Fig. 2 for $B/A = 3.57$, we get:

i) $k = 0.44 \quad \dots (1)$

ii) $\frac{\Lambda_P}{a^3} = 0.35 \quad \dots (2)$

iii) $\frac{Z_1}{a} = 0.29 \quad \dots (3)$

iv) $\frac{\Lambda}{a} ({}_1Z_z - {}_1Y_y) = 0.25 \quad \dots (4)$

Substituting values in equation given in E-1.4, we get,

$$= \frac{2(1-0.062\ 5)}{0.206 \times 10^6 \times 0.002\ 98}$$

$$= \frac{3.05}{10^3}$$

From (2) we get:

$$a = 3 \sqrt{\frac{\Lambda P}{0.35}}$$

$$= 3 \sqrt{\frac{3.05 \times 356\ 495}{10^3 \times 0.35}}$$

$$= 3 \sqrt{3\ 106.6}$$

$$= 14.59$$

From (4) we get:

$$({}_1Z_z - {}_1Y_y) = 0.25 \frac{a}{\Lambda}$$

$$= \frac{0.25 \times 14.59 \times 10^3}{3.05}$$

$$= 1\ 195.9\ \text{N/mm}^2$$

= maximum differential of stress components

$$\therefore \text{Max shear stress} = \frac{1}{2} ({}_1Z_z - {}_1Y_y)$$

$$= 597.95\ \text{N/mm}^2$$

Allowable shear stress

$$= 2.41 \times \text{BHN (see 5.4.2)}$$

$$= 2.41 \times 255$$

$$= 614.55\ \text{N/mm}^2$$

This is greater than the actual shear stress 597.95 N/mm². Hence safe.

- f) Check for contact stress

Substitution in (e) (3)

$$Z_1 = 0.29 a$$

$$= 0.29 \times 14.59$$

$$= 4.231\ \text{mm}$$

Semi-major and semi-minor axis of ellipse of contact are:

$$a = 14.59\ \text{mm}$$

$$b = k.a$$

$$= 0.44 \times 14.59$$

$$= 6.42\ \text{mm}$$

Contact stress = $\frac{3}{2} \times \frac{p}{\pi \times ab}$

= $\frac{3 \times 356\,495}{2 \times 3.14 \times 14.59 \times 6.42}$

= 1 818.1 N/mm²

E-2.3 Allowable Stress (If Used on u/c Crest Gate)

In accordance with Annex F, allowable stress:

= 2.4 UTS

= 2.4 × 883

= 2 119.2 N/mm²

This is greater than actual stress 1 818.1 N/mm². Hence safe.

E-2.4 Allowable Stress (If Used on Sluice Gate)

In accordance with Annex F, allowable stress:

= 2.1 × 883

= 1 854.3 N/mm²

This is greater than actual stress 1 818.1 N/mm². Hence safe.

E-2.5 Minimum Depth of Penetration of Hardness Required

= 2.0 × Z₁

But $\frac{Z_1}{a} = 0.29$

Therefore, Z₁ = 0.29 a

= 0.29 × 14.59

= 4.231 mm

∴ Minimum depth of penetration of hardness

= 2 × 4.231 = 8.462 mm (say 9 mm).

ANNEX F

(Clauses 5.4.2.1 and 5.4.3.1)

PERMISSIBLE LINE AND POINT CONTACT STRESSES

| | <i>Crest Gates and Low Head Sluice Gates</i> | <i>Medium and High Head Sluice Gates</i> |
|---------------|--|--|
| Line contact | 1.6 × UTS | 1.4 × UTS |
| Point contact | 2.4 × UTS | 2.1 × UTS |

NOTE — UTS = ultimate tensile strength in N/mm².

ANNEX G

(Clause 5.5.2)

TYPES OF RUBBER SEALS RECOMMENDED FOR DIFFERENT CLASSES OF GATES

- a) *High Head* — Double stem type (preferably with cladding) for top and top corner seals, music note seal for side seal.
- b) *Medium Head* — Solid bulb music note type, and
- c) *Low Head* — Hollow/solid bulb music note type or flap or premoulded L-type

NOTE — Wedge type seal may be used at the bottom of the gate when it comes to rest on the sill. If the gate slides on the face of an opening, musical note or double stem type seals may be used.

ANNEX H

(Clause 5.12)

TOLERANCES FOR EMBEDDED PARTS AND IN COMPONENTS OF GATE

| Components | | Classification | |
|------------------|--|------------------------|-----------|
| | | Low and Medium Head | High Head |
| | | mm (2) | mm (3) |
| (1) | | | |
| A Embedded Parts | | | |
| 1 | Track Plates | | |
| 1.1 | Alignment in plane parallel to flow | ±1.0 | ±0.5 |
| 1.2 | Distance between centre line of opening and track | ±1.5 | ±1.0 |
| 1.3 | Coplanerness | ±1.0 | ±0.5 |
| 2 | Guides | | |
| 2.1 | Alignment in plane parallel to flow | ±1.0 | ±1.0 |
| 2.2 | Distance between centre line of opening and face of guide | ±1.0 | ±1.0 |
| 3 | Side Seal Seats | | |
| 3.1 | Alignment in plane parallel to flow | ±2.0 | ±1.0 |
| 3.2 | Distance between centre line of opening and side seal seat | ±1.5 | ±1.0 |
| 3.3 | Coplanerness | ±1.0 | ±0.5 |
| 4 | Top Seal Seat | | |
| 4.1 | Alignment | ±2.0 | ±1.0 |
| 4.2 | Height above sill | ±3.0 | ±2.0 |
| 4.3 | Coplanerness with side seal | ±1.5 | ±1.0 |
| 5 | Critical Dimensions | | |
| 5.1 | Centre-to-centre distance between track plates | ±3.0 | ±2.0 |
| 5.2 | Centre-to-centre distance side seal seats | ±3.0 | ±2.0 |
| 5.3 | Face-to-face distance between guides | ±2.0 | ±2.0 |
| | | -1.0 | -1.0 |
| 5.4 | Face of track to face of side seal seat | +0.0 | +0.0 |
| 5.5 | Face to track to centre line of guide | ±2.5 | ±2.0 |
| B Gate | | | |
| 1 | Wheels | | |
| 1.1 | Alignment of treads in zero eccentricity position | 1.5 | 1.5 |
| 2 | Side and Top Seal Base | | |
| 2.1 | Alignment | ±1.0 | ±0.5 |
| 2.2 | Coplanerness | ±1.0 | ±0.5 |
| 3 | Critical Dimensions | | |
| 3.1 | Centre-to-centre distance between seal bases | ±2.0 | ±1.0 |
| 3.2 | Centre-to-centre distance between centre line of wheel treads | ±2.0 | ±1.0 |
| 3.3 | Face-to-face distance between faces of guide shoes or guide rollers | ±3.0 | ±2.0 |
| 3.4 | Face-to-face distance between wheel tread to side seal base | +2.0 | +1.0 |
| | | -0.0 | -0.0 |
| 3.5 | Distance between faces of wheel tread and centre line of guide shoe/roller | ±2.5 | ±1.5 |

ANNEX J*(Foreword)***COMMITTEE COMPOSITION****Hydraulic Gates and Valves Sectional Committee, WRD 12**

| <i>Organization</i> | <i>Representative(s)</i> |
|---|--|
| In personal capacity (2047, Pocket 2, Sector D, Vasant Kunj, New Delhi) | SHRI N. VISHWANATHAN (Chairman) |
| Bhakra Beas Management Board, Punjab | DEPUTY CHIEF ENGINEER EXECUTIVE ENGINEER (<i>Alternate</i>) |
| Bharat Heavy Electricals Ltd, Bhopal | SHRI A. S. SRIVASTAVA SHRI S. R. RATHORE (<i>Alternate</i>) |
| Central Design Organization, Nasik | SHRI V. C. SHELKE |
| Central Electricity Authority, New Delhi | SHRI R. K. RUSTAGI |
| Central Water and Power Research Station, Pune | SHRI R. M. SINNARKAR SHRI S. L. PATIL (<i>Alternate</i>) |
| Central Water Commission, New Delhi | DIRECTOR GATES (E&Ne) DIRECTOR (GATES-Nw&S) (<i>Alternate</i>) |
| Cimmco Ltd, Bharatpur | EXECUTIVE PRESIDENT SENIOR MANAGER (DESIGN) (<i>Alternate</i>) |
| M/s Gea Energy System (India) Ltd, New Delhi | SHRI K. C. BAHETY SHRI A. G. K. MURTY (<i>Alternate</i>) |
| Haryana State Minor Irrigation (Tubewell) Corporation Ltd, Chandigarh | SHRI S. P. GUPTA SHRI R. S. CHAUHAN (<i>Alternate</i>) |
| Himachal Pradesh State Electricity Board, Sunder Nagar, H. P. | CHIEF ENGINEER (DESIGN) SHRI D. K. VAIDYARA (<i>Alternate</i>) |
| Irrigation Department, Government of Punjab, Chandigarh | CHIEF ENGINEER (RSDD) DIRECTOR (M&E) (<i>Alternate</i>) |
| Irrigation Research Institute, Roorkee | CHIEF ENGINEER (DESIGN) SUPERINTENDING ENGINEER (<i>Alternate</i>) |
| National Hydroelectric Power Corporation Ltd, Haryana | SHRI A. K. SACHDEVA SHRI G. S. SHARMA (<i>Alternate</i>) |
| Orissa Construction Corporation Ltd, Orissa | DIRECTOR (MECHANICAL) SENIOR MANAGER (DESIGN) (<i>Alternate</i>) |
| Public Works Department, Government of Tamil Nadu, Chennai | SHRI M. DURAIRAJ SHRI T. KRISHNASWAMY (<i>Alternate</i>) |
| Texmaco Ltd, Kolkata | SHRI S. R. SINHA SHRI UDAYAN BANERJEE (<i>Alternate</i>) |
| Triveni Structurals Ltd, Allahabad | SHRI J. P. MISHRA SHRI B. P. SINGH (<i>Alternate</i>) |
| Tungabhadra Steel Products Ltd, Karnataka | SHRI HUSSAIN BIN ALI SHRI Y. S. CHANDRASHEKARAIHAH (<i>Alternate</i>) |
| Water Resources Development Training Centre, Roorkee | PROF GOPAL CHAUHAN |
| BIS Directorate General | SHRI S. S. SETHI, Director & Head (WRD) [Representing Director General (<i>Ex-officio</i>)] |

Member Secretary

SHRIMATI ROSY DHAWAN
Joint Director (WRD), BIS

(Continued from second cover)

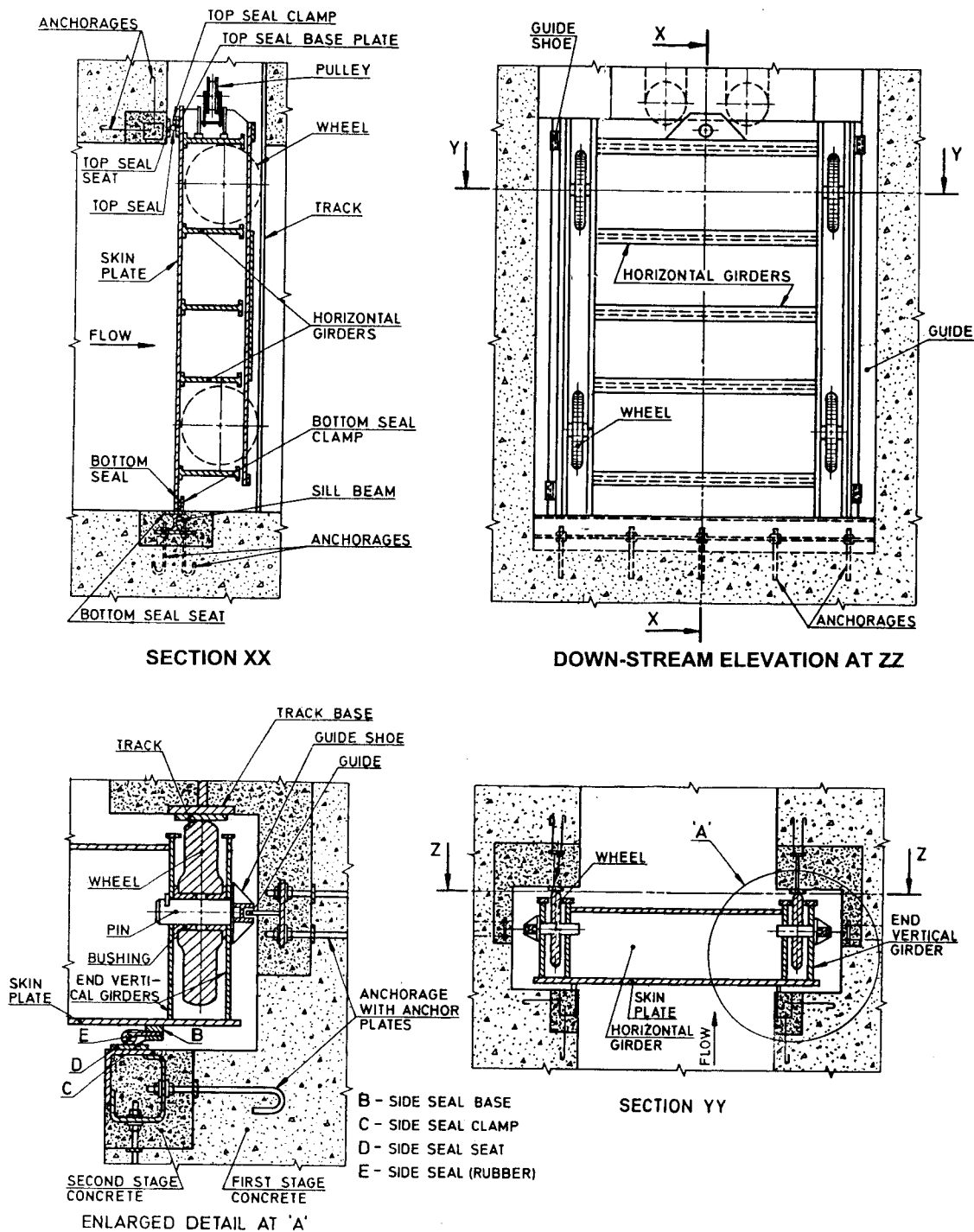


FIG. 1 TYPICAL ARRANGEMENT OF VARIOUS COMPONENTS OF FIXED-WHEEL GATES

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